INTRODUCTION

Identification of handwriting is one of the important aspects of questioned document analysis/examination. There are no magical powers or formulas at the disposal of document examiners for the identification of handwriting, rather it is the consistent efforts and years of experience which enable them to recognize and compare the characteristics of questioned and authentic documents.[1]

Handwriting of a person is a brain function where hand merely acts as a device to carry out the instructions given by the brain. Document experts testify that in accordance with the principle of individuality, no two individuals can have the exact same handwriting.[1,2] Though there can be some marked resemblances in the writing of two different persons owing to the several characteristics or factors that make up the writing of an individual.[3] The uniqueness of handwriting makes this an important evidence akin to fingerprints, hair, blood, footprints, etc.[1]

There are several factors which affect the writing of a person that are responsible for the individual variations.[1,3] The variations occur as a result of mechanical, mental and physical factors making it almost impossible to be reproduced exactly in the same manner by even an individual and/or two different individuals. Thus, characteristics like angularity, speed, pressure, spacing, slope, connections, pen movement, finger dexterity, writing surface, type of pen used, etc. offer the variations to be noticed by the forensic document experts.[4] Other characteristics such as margins, insertions, alignment, spacing, punctuation, grammar, and spellings are individualistic in nature and can prove to be resourceful to individualize the author of a writing.[5] The analysis of handwriting requires a very broad knowledge at various levels of observation. For the identification of a writer in a large collection of known/unknown samples on the basis of a small snippet of handwriting, multi-level knowledge is taken into account. [4, 5]

Principles of Handwriting [6]

1) "Handwriting is not identified from the general and pictorial appearance of letters rather it is identified by the combination of all elements and qualities related with the form of letters derived from writing element".
2) "The writing characteristics which are almost personal have more identifying value, though other personal and class characteristics also contribute to final conclusions".
3) "The handwriting movement is displayed by various elements such as speed, rhythm, writing pressure, pen position, shading, skill and line quality etc."
4) "The best writing standards are those which were written under similar conditions as prevailing at the time of writing the matter under investigation".
5) "A questioned writing was written by a particular person if the variations in the questioned writings fall within the range of variations in specimen writings".
6) "A questioned writing was not written by a particular person if there exist material dissimilarities between writing characteristics and the range of variations in the questioned writings does not fall within the range of variations in the specimen writings".

The examination of handwriting relies on comparison at three different levels. First, the document examiner identifies whether those writings are pictorially similar or not. Secondly, if the pictorial appearance of the writings appears to be similar, a detailed and in-depth examination is conducted to determine whether all the letters and other characteristics have the same pattern of formation or not. Thirdly, once the patterns are also found to be similar, an extensive detailed examination is done to determine if they were written by the same person or not. [1, 5]

An examination of handwriting for comparison is incomplete until all possible relative relationships of the writings are determined and compared. Determining the individuality is an important parameter and is a decisive part of the handwriting identification process.[1,3,4] After analyzing and evaluating all the features and characteristics of handwriting, based on the frequency of their occurrence or uncommonness of those characteristics and combined significance of all those characteristics, the examiner achieves enough clue for forming an opinion whether a specific writing sample is different from others or not.[5] After attaining a level of certainty, the examiner can substantiate whether the writings are of the same writer or of different ones.[1.5]

'Handwriting' also known as 'brain writing' is also said to be affected by hormonal changes and neuro-motor functioning. There can be discriminatory features which are observed in the writing of males and females which help in the determination of the gender of the writer. Sex identification is of great importance in narrowing down the suspects and thus aiding in the investigation.[3,4]

Handwriting is a conscious act which is influenced by various factors like the ability to imitate, the mental conditions existing at the time of writing, etc. Handwriting analysis when assisted with graphology helps in establishing the personality traits of the individual. These personality traits vary in individuals with different professions which enable the identification of profession on the basis of handwriting characteristics.

Heredity has an important role in determining the handwriting characteristics of a person. It may be in the form of pattern of formation of letters, handedness, position of holding the pen, ability to learn, ability to think etc. Since, the child observes his parents from the beginning; it seems to have a greater impact in molding the way he/she writes. These writing habits may include position of holding the writing instrument, the hand used for writing, posture of the body while writing, among others.. [7, 8, 9]

REVIEW OF LITERATURE

Different research groups have carried out work for the analysis of handwriting for the identification of individuals, for the determination of sex, for determining handedness etc. Following works are presented here.

McKeever, W.F. (1979) examined the incidence of inverted (IHP) and non-inverted (NHP) hand postures in normal left-handers. Hand posture was found to be reliably classifiable; males employed the IHP significantly more often than females. Results of these studies suggested that, because of its association with familial sinistrality, hand posture is not a wholly unique new variable and that hand posture appears less promising. [8]

DeFries, J.C. et al. (1979) studied different measures of familial resemblance for members of the two largest ethnic groups tested in the Hawaii Family Study of Cognition. Median spouse correlations (corrected for differences in test reliability) for 15 individual tests of specific cognitive abilities are 0.15 and 0.12 for Americans of European and of Japanese ancestry, respectively. With regard to the regressions of offspring on midparent value, corresponding median values are 0.50 and 0.35. Results of hierarchical multiple regression analyses, as well as the ordering of single-parent/single-child and sibling correlations, provide no evidence to support the hypothesis that spatial ability is influenced by a sex-linked, recessive gene.[9]

Hamid, S. and Loewenthal, K.M. (1996) inferred gender from handwriting in Urdu and English handwriting samples from 30 donors. Inferences about gender were made reliably and accurately in both Urdu and English. Levels of accuracy (about 68%) were similar to those reported in studies of handwriting in English. Judged gender of handwriting was significantly stable across the two languages studied and these effects were found to be relevant for the study of gender roles and gender stereotyping in assessment. [10]

Cha, S.H. (2001) stated the importance of distance measures like element, histogram, probability density function, string and convex hull distances, in the comparison of handwriting samples and in determining whether the two documents were written by same person or not. [11]

Leedham, C.G. et al. (2003) examined and extracted 7 to 14 different features from four different letters (“y”, “d”, “f” & “t”) on a total of 3077 letters from 30 different writers. These features were extracted with about 88% accuracy and can be used to assess the similarity of different writing samples. [12]

Beech, J.R. and Mackintosh, I.C. (2005) investigated whether there could be a biological determinant of the judged gender of handwriting and investigated the potential interplay between these variables and sex role identification. These findings suggested that prenatal hormonal influences can affect female handwriting performance and might even affect developmental inter-hemispheric differences, but do not appear to impact on males.[13]

Marquis, R. et al. (2007) tested the hypothesis of shape invariance of handwritten closed loops across increasing size by Fourier methodology. Most of the writers presented similar modifications when increasing the size of the loops; they produced enlarged loops significantly more round and less slanted towards the right or the left. Furthermore, a discrimination was demonstrated between the writers on the basis of the enlarged loops, with a correct classification rate superior to 90%, whatever the letter (a, d, o or q).[14]

Liwicki, M. et al. (2007) addressed the problem of classifying handwritten data with respect to gender and handedness. For the classification state-of-the-art classification methods were used to distinguish between male and female handwriting, and left- and right- handedness. Two classification systems based on Support Vector Machines and the other one based on Gaussian Mixture Models were evaluated which showed an improved performance over human-based classification.[15]

Saran, V. et al. (2013) studied the resemblance of slant in handwriting of closed genotypic family members were studied in a sample of 360 families, using computational method based on MATLAB, followed by the statistical evaluation of the parameters. Significant resemblances of slant in handwriting of offspring's of family members were observed. However, handedness, and gender may be involved in the formation of this behavior.[16]

Kumar, S. et al. (2013) attempted to ascertain the gender of writers by a statistical study of characteristic elements found in their handwriting. The variations in the writing of a hundred males and a hundred females was statistically analyzed and the results were found to be encouraging from the point of view of determination of the gender of the writer which might prove to be successful in narrowing down the suspect.[17]

Saini, M. et al. (2015) examined handwriting samples to study the inheritance of the writing characteristics among parents and their biological offspring. Resemblances in the handwriting features of parents-off springs were studied using computational features based on MATLAB 8.3 software.[18]

Upadhyay, S. et al. (2017) studied 130 writing samples for the differentiation of gender by feature extraction method and z-tests. Significant differences were obtained in the handwriting of males and females.[19]

Sahu, M. et al. (2017) examined the various minute features possessed in handwriting and classified them into macro and micro features in 130 samples of handwriting. These features were further used to discriminate and divide handwritings on the basis of its capability of determining or predicting the gender of the writer. Promising results were observed proving the handwriting features to be gender identifying.[20]

Kiran P. and Sridhar D. (2017) studied 50 samples of handwriting to determine the similarities in the handwriting characteristics of parents and offspring. While analyzing the general correlation of handwriting characteristics between the parents and the off-springs, they found that there is highest level of similarity in pen lifts and a low level of similarity was found in the pressure applied while writing.[21]

Topaloglu M. and Ekmekci S. (2017) detected gender of individuals by making use of 133 attributes. A decision tree and lists of rules were created with some algorithms with the purpose to detect the gender of the person by making a character analysis of the handwriting with the help of decision tree formation methods in data mining. The analysis showed that it is possible to detect the gender of a person with the use of the specified attributes with a success level of 93.75% with ID3 algorithm.[22]

Sangwan, A. and Chauhan, A. (2018) studied the handwriting to determine any similarity among siblings because it is considered that both might have learnt or adopted the same characteristics from same school, parents or from any group. During this study, it was observed that t-value between the handwriting characteristics of siblings was -1.4236 and the p-value was 0.0925 at (0.0925 <0.10). It shows that the handwriting of siblings is influenced from each other, teacher or parents and bear an elevated level of significance.[23]

Gattal, A. et al. (2018) proposed a handwriting based gender recognition system which exploited texture as the discriminative attribute between male and female handwriting. The technique proved to be a better method than the other script dependent and script independent modes.[24]

RATIONALE FOR THE STUDY

As several questions are raised in the process of examination of questioned documents, there is a need to carry out research to determine the profession, genotypic relationships and gender of the writer.

In cases of family conflicts where there are disputes involving wills, property documents, etc. the chances of a family member being the culprit is more probable. So, identifying the resemblance of the characteristics among the family members is an important area for study. Previously conducted researches on the study of inheritance pattern of handwriting characteristics made use of software and algorithms which are complicated and not easy to replicate. Hence, a simplified method of analysis is deemed essential for use in routine casework analysis.

There may be variations in the writing characteristics in the individuals of different professions. Determination of the profession of an individual based on the handwriting characteristics analysis becomes an imperative task. This fosters the need of the present study.

Determining the gender of the writer is crucial for narrowing down the pool of suspects in the process of investigation. Gender identification with the help of handwriting can incite an important breakthrough in the field of questioned document analysis. In the earlier studies, sample sizes were quite small, and hence, cannot provide a generalized result on the basis of observations. In the current study, a larger sample size will be used for the analysis. The additional individual characteristics like direction of the formation of the letters, buckles of the alphabets, cusps, eyelets, troughs, retracing etc. will be analyzed for the differentiation of gender. [3]

OBJECTIVES OF THE STUDY

The objectives of the present study are:

- To determine the variations and similarities in the characteristics of the handwriting of individuals having different professions.
- To study the similarities and differences in the of handwriting characteristics of genotypically related individuals.
- To study the difference in the characteristics of handwriting of different gender.

METHODOLOGY

Ethical Clearance: The informed/written consent of the participating individuals would be enrolled after explaining to them the purpose of the study.

Exclusion and Inclusion Criterion: Healthy consenting individuals aged between 18 and 50 years would be included in the study. Individuals with any pathological disorder like leprosy, spinal cord disorder, laceration, injury, scar, disease, fracture, amputation or history of any surgical procedures of the hand would be excluded from study. Any subject having any signs of illness which hamper the hand movement while writing will be eliminated from the study.

Sample and sample size: Stratified random sampling method would be used for this study. The demographic details, educational status, handedness etc. will be obtained from the subjects. They shall be provided the writing material and sample text.

Set 1: Handwriting samples from around 500 individuals of five different professions viz. Doctors, Engineers, Teachers, Lawyers, Businessmen (i.e. 100 samples each = 50 males and 50 females each) will be taken. This set of samples will be used for studying the difference between characteristics in different professions.

Set 2: Next set of samples will include handwriting samples of 200 families (mother, father, and offspring) to study the inheritance pattern of the characteristics of handwriting.

Set 3: Samples collected for both the above categories will be further used to study the variations in the handwriting characteristics of males and females.

For obtaining the handwriting samples, London Letter (&/or its suitable modified version) or some similar sample script will be used. London Letter is a standard text of extended writing composed in such a way that each letter of the alphabet is used in both its upper and lower case form and all the numerals are used in different combination.[1] The subjects will be made to write the text on plain white A4 sized paper (70 gsm).

Method of Analysis:

The handwriting samples will be subjected to morphological and comparative analysis. Various established as well as novel class and individual characteristics of handwriting like direction of the formation of the letters, buckles of the alphabets, cusps, eyelets, troughs, retracing etc. will be identified manually/digitally using appropriate instruments such as hand-held illuminated microscope, stereoscope, computer aided method, etc. Qualitative and quantitative analysis will be done and the data obtained will be subjected to various statistical tests.

EXPECTED OUTCOME

On completion of this study,

- It may be possible to determine the profession of the individual based on the study of the handwriting characteristics.
- It may be possible to establish the genotypic relation of the writer and the effect of heredity on handwriting.
- It may be possible to estimate the gender of the writer of a particular handwriting sample.

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Chapter Outline

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